Diet of the Striped Legless Lizard *Delma impar* (Squamata: pygopodidae) in a western (basalt) plains grassland, Victoria

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ABSTRACT

This study examined diet composition and specialisation of the Striped Legless Lizard *Delma impar*, a species of conservation significance in southeastern Australia. A small sample of 25 faecal pellets was collected opportunistically during the course of fauna surveys in the Derrimut Grasslands Reserve, Victoria. Their contents were examined and the invertebrate remains identified to the level of order. Invertebrate prey availability was estimated using samples collected from pitfall traps and dietary specialization was calculated using Levins (1968) standardized measure of niche breadth. A low measure was recorded (0.05–0.07) and mainly cricket, spider and noctuid moth were found in the faecal pellets. This suggests that the Striped Legless Lizard is probably a specialized arthropod feeder. However, the small faecal pellet sample size, potential biases in the measurement of prey availability and possible uneven prey availability due to palatability constraints, may have differentially influenced this result. Seasonal prey shifts and a flexible foraging strategy are also suggested by the results, though more detailed work is required on the feeding ecology of this threatened species.

INTRODUCTION

The Striped Legless Lizard *Delma impar* is a member of the endemic Australasian family of lizards, the Pygopodidae, or flap-footed lizards. It has the southern-most distribution of all pygopodids and is found in disjunct populations throughout lowland tussock grasslands in the extreme south-east of South Australia including: south-central and western Victoria; the Australian Capital Territory (ACT); and south-east New South Wales (NSW), west of the Great Dividing Range (Coulson 1990; Osborne *et al.* 1993; Shea 1993).

Prior to 1990, very little biological information was available for the Striped Legless Lizard, apart from its taxonomic relationship to other pygopodids (Kluge 1974) and general observations of habitat (Jenkins and Bartell 1980; Cogger 1992), reproductive period and diet (Patchell and Shine 1986) and activity period (Martin 1972). In a review of the ecology and habitat requirements of the Striped Legless Lizard in Victoria, Coulson (1990) highlighted its uncertain status and poorly-known biology. Since this preliminary work, and the subsequent recognition of the conservation significance of this species, there has been an increase in studies examining the distribution, habitat and behavioural ecology of the Striped Legless Lizard in Victoria (Moro 1990; Kutt 1991; Banks 1992; Kutt 1992; Mills 1992; Webster *et al.* 1992; Kutt 1993; Hadden 1995) and the ACT (Kukolic 1992, 1993, 1994; Kukolic *et al.* 1994; Osmond 1994; Dorrough 1995; Nunan 1995).

Though members of the genus *Delma* were thought to be generalist invertebrate feeders (Bustard 1970; Patchell and Shine 1986), the specific diet of the Striped Legless Lizard was unknown. Coulson (1990) undertook a preliminary examination of diet composition using faecal pellet analysis, while more recently Nunan (1995) completed a detailed study of the diet and feeding ecology of the Striped Legless Lizard in the ACT. During the course of surveys of its distribution and habitat preferences in the Derrimut Grassland Reserve on the outskirts of Melbourne (Kutt 1991, 1992), some faecal pellets were collected and their contents examined. This paper reports the results of the diet analysis and discusses them in the context of the detailed work of Nunan (1995) in the ACT.

METHODS

Study sites

The survey sites were located in and adjacent to the 154 ha Derrimut Grasslands Reserve, approximately 20 km west of the city of Melbourne, Victoria. The vegetation consists mainly of native grasslands dominated by Kangaroo Grass *Themeda triandra* and grassy wetlands of high botanical significance (Craigie and Stuwe 1992).

Trapping and pellet collection

Striped Legless Lizards were trapped using a combination of pitfall trap grids (consisting of 50 traps) and lines of 10 pitfall traps. The surveys were conducted during the spring and summer of 1990–91 and 1991–92, the results of which are reported in Kutt (1991, 1992, 1993). Any Striped Legless Lizards trapped was kept overnight for measurement and the collection of faecal pellets. To facilitate safer handling, each lizard was partially immobilized by cooling it for a short period (3–4 minutes) in a refrigerator (approximate temperature 4°C). If an animal was cooled for a slightly longer period of 5–10 minutes, individuals could regularly be induced to deposit a faecal pellet. This technique was found to work consistently with no apparent ill-effect to the animals.

Twenty-five faecal pellets were collected for analysis, air dried and preserved in small plastic bags. They were later immersed in 70% ethanol, then teased apart for inspection and identification of the constituent food items using a binocular dissecting microscope. Invertebrates were identified as far as practicable, usually to the level of family or order, and counted.

Prey availability

In order to estimate the availability of prey, invertebrate samples were collected from the trap sites in February 1991 and February 1992. The first sample was obtained by collecting all invertebrates that fell into the large pitfall traps over a period of one week. These were then preserved in 70% ethanol. The second collection was made using insect pitfall traps: small plastic cups, with a mouth diameter of 70 mm, set flush with the soil surface and left open for a one week period. Each contained about 1 cm depth of 70% ethanol as an invertebrate preservative. One hundred pitfall traps were set 1 m from the fence-line of the pit-fall traps set to capture the Striped Legless Lizards. In both cases, invertebrates were sorted and identified as far as practicable.

Measure of degree of diet specialization

The degree of specialization within the diet of Striped Legless Lizard at the study area was examined using Levins (1968) standardized measure of niche breadth. This provides an index of a species feeding behaviour using potential prey availability against prey consumption and is calculated from the equation: $B = 1/$ (No. possible food categories) p_j^2 ($j = 1....n$), where B = Levins measure of niche breadth, p_j = proportion of the food items that are in the category j. This measure is then standardized to a 0–1 scale by: $B_A = B-1/n-1$, where, B_A = Levin's standardized measure of niche breadth, B = Levin's measure of niche breadth, n = number of possible food categories. A value close to one indicates a diet generalist, while a value close to zero indicates a diet specialist.

RESULTS

Invertebrate species from 10 orders were collected from the pitfall traps in 1990–91 and 14 orders in 1991–92. Of these, six orders were recorded as prey items in the scat analyses in 1990–91 and three orders as prey items in 1991–92 (Figs 1 and 2). In 1990–91, 28 prey items were recorded in 15 scats (mean = 1.86 items per scat) while in 1991–92, 16 items were recorded in 10 scats (1.60 per scat). In both the 1990–91 and 1991–92 sample, crickets (Order Orthoptera, Gryllidae) and moth larvae (Order Lepidoptera, Noctuidae) represented the greatest proportion of total prey items found within the scats, with spiders (Aranae) being the third most frequent (Table 1).

A comparison of the availability of prey items in each invertebrate order (mean percentage frequency of invertebrates collected in each pitfall trap) with the consumption of prey (percentage frequency of prey items as a proportion of the total number of scats) for each sampling period indicates that the pattern of invertebrate orders over these two measures are widely disparate (Figs 1 and 2). Levins standardized measure of niche breadth was low for both sample sets (0.07 and 0.05), indicating a degree of specialization in the diet.

Seasonality of *D. impar* diet was assessed by examining the proportion of each prey item in faecal pellets on a monthly basis. As the sample size was small for each season, results were pooled to achieve a spread from November to February. There was a trend for high proportions of lepidopteran prey in November to January with an increasing number of orthopteran prey from December to February (Fig. 3), though a chi-square contingency table did not indicate any significant differences in diet between each month ($c^2 = 14.631$, df = 15, $p = 0.478$).

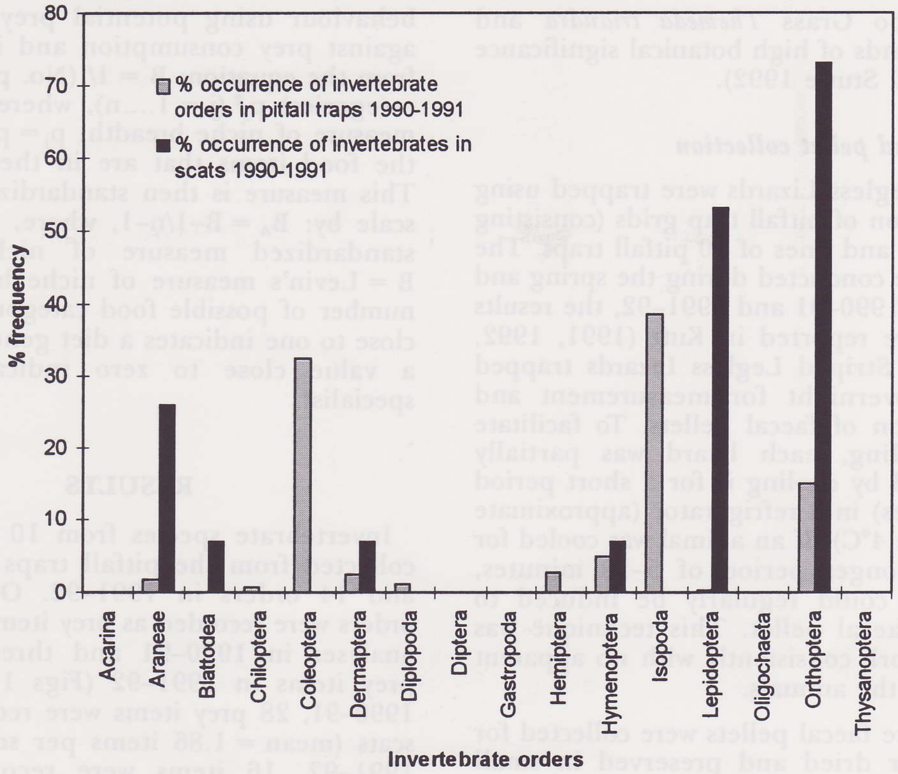

Figure 1. Percentage frequency of invertebrate orders within Striped Legless Lizard scats and pitfall traps summer 1990–1991.

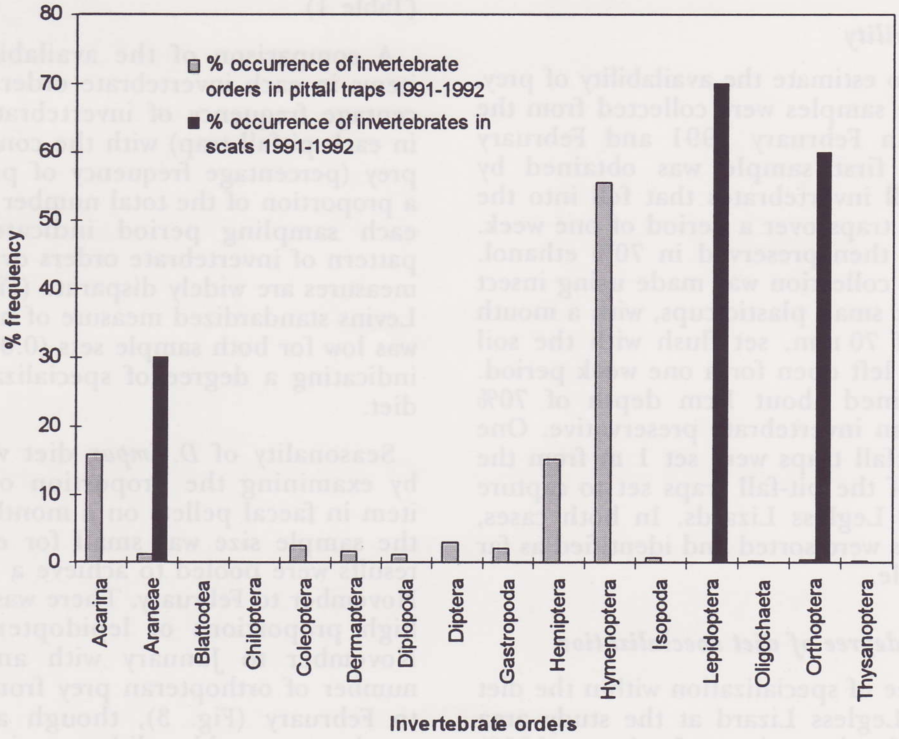

Figure 2. Percentage frequency of invertebrate orders within Striped Legless Lizard scats and pitfall traps summer 1991–1992.

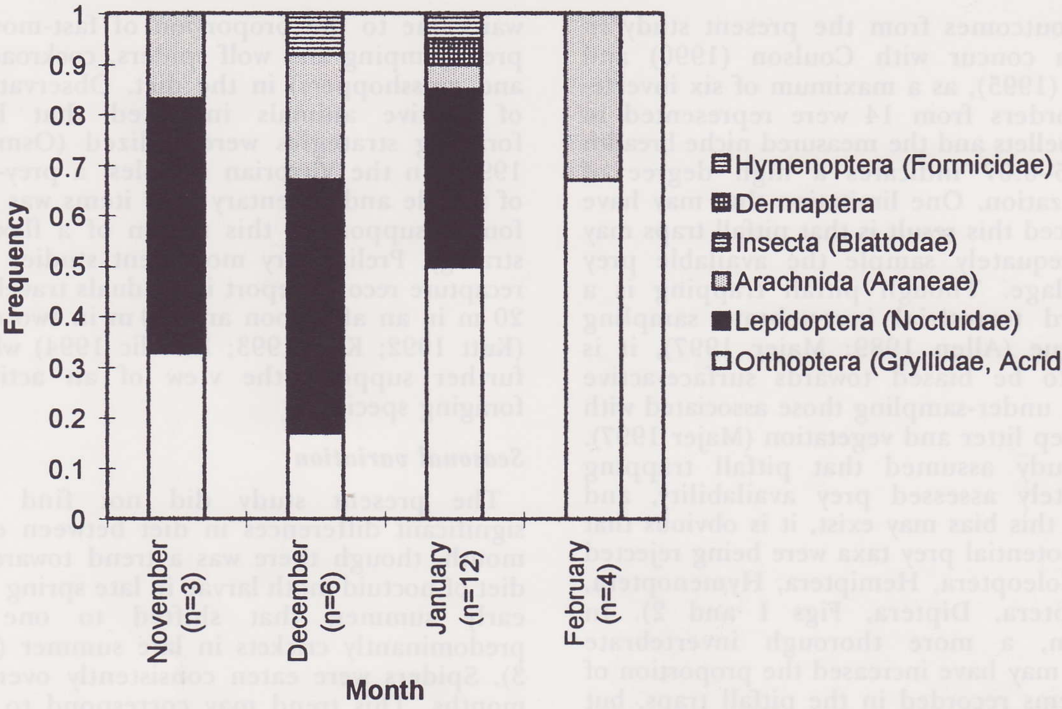

Figure 3. Percentage frequency of prey items occurring in Striped Legless Lizard faecal pellets for each month collected.

Table 1. Diet and niche breadth for Striped Legless Lizard at Derrimut Grasslands Reserve, 1990–1991 and 1991–1992.

Prey taxa		1990–1991		1991–1992	
Order	Family	Total prey items found in all faecal pellets examined	Total number of faecal pellets in which particular prey type was found	Total prey items found in all faecal pellets examined	Total number of faecal pellets in which particular prey type was found
Arachnida	Araneae	4	4	3	3
Insecta	Blattodea	1	1	0	0
Orthoptera	Acrididae	3	3	0	0
Orthoptera	Gryllidae	9	8	6	6
Dermaptera		1	1	0	0
Hymenoptera	Formicidae	1	1	0	0
Lepidoptera	Noctuidae (larvae)	9	8	5	5
Lepidoptera	Noctuidae (adult)	0	0	2	2
Total number pellets analysed		15		10	
Total number prey items in scats		28		16	
Levin's standardized measure of niche breadth		0.07		0.05	

DISCUSSION

Diet

Members of the pygopodid genus *Delma* were previously all thought to be generalist invertebrate feeders, though no specific reference was made to the diet of the Striped Legless Lizard *Delma impar* (Bustard 1970; Patchell and Shine 1986). Coulson (1990) presented preliminary indications that the species was specialized in its diet. He examined the contents of faecal pellets of Striped Legless Lizard trapped at the Derrimut Grasslands Reserve and from a total of 15 samples, the remains of crickets (Orthoptera: Gryllidae), spiders (Arachnida: Salticidae, Miturgidae) and mainly larval nocuid moths (Lepidoptera: Noctuidae) were identified. By contrast, invertebrates collected from the pitfall lines comprised 16 orders (Coulson 1990). In the ACT, Nunan (1995) concluded that the Striped Legless Lizard was a selective arthropod feeder, by both the lack of a number of abundant invertebrate types in the diet of the Striped Legless Lizard and on a calculated niche breadth that was closer to the specialist end of the scale.

The outcomes from the present study in Victoria concur with Coulson (1990) and Nunan (1995), as a maximum of six invertebrate orders from 14 were represented in faecal pellets and the measured niche breadth of 0.05–0.07 indicates a high degree of specialization. One limitation that may have influenced this result is that pitfall traps may not adequately sample the available prey assemblage. Though pitfall trapping is a standard terrestrial invertebrate sampling technique (Allen 1989; Majer 1997), it is likely to be biased towards surface-active species, under-sampling those associated with soil, deep litter and vegetation (Majer 1997). Our study assumed that pitfall trapping adequately assessed prey availability, and though this bias may exist, it is obvious that many potential prey taxa were being rejected (e.g., Coleoptera, Hemiptera, Hymenoptera, Dermaptera, Diptera, Figs 1 and 2). In addition, a more thorough invertebrate sample may have increased the proportion of prey items recorded in the pitfall traps, but correspondingly would have been likely to increase the proportion of other taxa (possible food catagories) recorded, thus maintaining the low measure of niche breadth.

In reality, some insects are likely to be unavailable to the Striped Legless Lizard due to unpalatability from predator-defence mechanisms (slimy or waxy coverings, urticating hairs, spiny processes, tough exoskeletons, cryptic behaviour, mimicry, chemical defences) and different activity periods (Norris 1991). Prey size may also be an influence on diet choice, however many crickets and moths recorded from faecal pellets were up to 40 mm in size (authors' unpubl. data). This potential for many taxa to be unsuitable prey items for the Striped Legless Lizard strengthens the view that specialization rather than generalization is likely in their diet. However, future studies should assess in more detail the level of prey availability and in particular, other characteristics such as palatability and prey life history features that may constrain their consumption.

Foraging strategy

The Striped Legless Lizard has been invariably described as an ambush predator and an active arthropod feeder (Bustard 1970; Patchell and Shine 1986; Ehmann 1992). Nunan (1995) argued that the occurrence of slow-moving prey (such as lepidopteran larvae) was indicative of an active, widely foraging predator, though there was evidence of switching between strategies (to sit-and-wait) due to the proportion of fast-moving prey (jumping and wolf spiders, cockroaches and grasshoppers) in the diet. Observations of captive animals indicated that both foraging strategies were utilized (Osmond 1994). In the Victorian samples, a prey-mix of mobile and sedentary prey items was also found, supporting this notion of a flexible strategy. Preliminary movement studies and recapture records report individuals travelling 20 m in an afternoon and 60 m in two days (Kutt 1992; Kutt 1993; Kukolic 1994) which further supports the view of an actively foraging species.

Seasonal variation

The present study did not find any significant differences in diet between each month, though there was a trend towards a diet of noctuid moth larvae in late spring and early summer, that shifted to one of predominantly crickets in late summer (Fig. 3). Spiders were eaten consistently over all months. This trend may correspond to the changes in abundance of these species over summer due to their life history: the soft bodied larvae predominate in early summer, then crickets become numerous in late summer when the noctuid moths have metamorphosed. Nunan (1995) found little evidence of seasonal variation in diet selection of the Striped Legless Lizard, but indicated that, as in the present study, some observed shifts were possibly due to the seasonal life history of prey types.

CONCLUSION

The examination of Striped Legless Lizard diet in and adjacent to the Derrimut Grasslands Reserve support the conclusion of Nunan (1995) that this species is probably a selective arthropod feeder. In both Victoria and the ACT the Striped Legless Lizard predominantly feeds on spiders, noctuid moth larvae and crickets, though spiders seem to be more common in the diet in the ACT. This may be due to the slightly different habitat preferences for this species in each region (Hadden 1995; Dorrough 1995).

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provided an invaluable background and guide to the treatment of the data collected in this study. All trapping and handling of the animals was conducted under a Wildlife Act (1975) Research Permit No. RP 91-130 issued by the Department of Conservation and Environment.

All unpublished reports referenced in the text are held by the Striped Legless Lizard Working Group. Copies can be obtained by request from Chris Banks, the Convener, Striped Legless Lizard Working Group, Zoological Board of Victoria, PO Box 74, Parkville, Victoria, 3052.

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BOOK REVIEWS — BOOK REVIEWS

"Snakes in Question. The Smithsonian Answer Book" by Carl H. Ernst and George R. Zug, 1996.
CSIRO Publishing, Melbourne, Victoria.
203 pp. ISBN 0 643 05951 2.

There are only a handful of animal groups that engender widespread curiosity and fear in the general public, and therefore spark a rush of questions. Spiders, sharks, and snakes are such groups. In *"Snakes in Question"*, the second in the "Smithsonian Answer Book" series (after Sharks), two eminent North American herpetologists set out to answer virtually all the questions that two such herpetologists are likely to have encountered in their long careers.

The format of the book is straightforward. Questions are grouped in major sections, and within each of the sections questions generally follow a logical sequence. The answers to the questions are often supplemented by line drawings and photographs, both black and white and colour. Because the "bites" are small and easily digestible, the book not only makes an authoritative reference but also an interesting distraction for an idle moment. The major sections are snake biology, folk tales, giant snakes, snake bite, and snakes and humans. Something for everybody.

The two most admirable features of the book are its sound commonsense approach to snakes — no pandering to the sensational or adolescent, and its solid evolutionary underpinning. The reader is enlightened and entertained both with fascinating facts of snake biology and lore, and with good examples of the power of thinking in phylogenetic terms. An example of good sound advice is the directive concerning the release of a temporarily captive snake: "... it must be released at the exact locality where it was captured." And this on creationism: "... [it] does not qualify as science because it is not based on ... [the] test-and-modify principle." Amen.

Considering the background of the two authors, and no doubt the primary market, the book draws largely on North American examples. There are relatively few Australian examples, and they tend to involve the better known species. This is disappointing, but understandable.

There are no references in the body of the text — no doubt to avoid putting off the non-academically inclined. However, this makes it difficult to follow up particular topics that catch one's fancy. There are a few references in the back of the book arranged under the individual questions themselves, but I did not find these included information on some of the topics which piqued my interest. For example, I was unable to find any mention in the listed references in support of the statement that "... the folding-fang mechanism [of death adders] is very similar in appearance and operation to that of the vipers and pitvipers." From the morphology of its supporting bone, I am sceptical that the death adder fang can rotate (to a forward pointing position) to the extent that it can in vipers when the mouth is opened. Maybe I have overlooked the relevant paper in the literature. But until I stumble across it, I live on in ignorance and doubt.

There are not too many questions that do not get explicit coverage. The only two substantive ones, from my experience, that seemed to be missing are: "Can venomous snakes envenomate themselves?", and "How can some snakes digest such big meals so quickly after fasting for so long between meals?" Perhaps the detailed work in these two areas was too uncertain or new at the time of publication to be included.

One question was baffling for its inclusion: "Do snakes get cancer?" I have been fielding snake questions for a number of years, but I have never heard this one asked. Perhaps it reflects a particular concern of the North American audience.

The book is highly reliable in its information. The only item I picked up on was the statement that "any snake encountered in Australia is probably a venomous one". Considering that nearly 42% of the terrestrial snake fauna of Australia consists of nonvenomous species, this may be a bit over the top, especially as many of the nonvenomous species, such as pythons and some of the colubrids, are frequently encountered.

A final question that might be asked of the book itself is how the CSIRO came to be involved as the Australian publisher. Perhaps they were handed the book on a plate, and it was too good a potential money spinner to let go. But if their costs approximated what an entirely "new" work would have entailed, one might ask why they did not spend the money for a locally authored production. And let the North Americans read mostly about our snakes!

This book will make a great present for your snake-mad kid. Or alternatively, if you want to look good, get it yourself, read up on the sly, and amaze her the next time she asks.

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